

Notes on the benthic macrofauna of Agadir Bay (Atlantic Morocco)

Datos sobre la macrofauna bentónica de la Bahía de Agadir (Marruecos Atlántico)

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ABSTRACT

The macrofauna collected in 25 dredge hauls from subtidal soft bottoms (6-25 m) in Agadir Bay, Southern Morocco, is listed. Seventy species are identified, chiefly Mollusca but also some decapods, echinoderms, and polychaetes. The results show four main assemblages with a similarity above 50%. The community of soft bottoms is quite homogeneous within the bay and is comparable to the community of fine sands with *Chamelea striatula* - *Maetra corallina* as described by Glémarec (1969, 1973) and with the shallow well calibrated fine sandy bottoms (SFBC) or 'terrigenous' fine sandy bottoms (Pérès and Picard 1964; Ledoyer, 1968). Towards the deeper part there is an increase of *Ophiura texturata* together with an increase in mud content. A more significantly different community is associated to bottoms with rocks in the northern part of the bay. Almost half of the species identified belong to the temperate European (Atlanto-Mediterranean) faunal province whereas one quarter belong to the tropical West African province. Despite the modest sampling effort, there are five species of molluscs (*Nassarius goreensis*, *N. argenteus*, *Cuna gambiensis*, *Tellina rubicincta*, *Pandora oblonga*) new to the Moroccan fauna, indicating the need for a more thorough survey in the area.

RESUMEN

Se presenta una lista de las especies de la macrofauna recolectada en 25 dragados en fondos blandos sublitorales (6-25 m) de la Bahía de Agadir, Sur de Marruecos. Se identificaron 70 especies, principalmente moluscos, pero también decápodos, equinodermos y poliquetos. Los resultados de este estudio muestran cuatro grupos de especies con una similitud superior al 50%. La comunidad de fondos blandos es bastante homogénea dentro de la bahía y se corresponde con la comunidad de arenas finas con *Chamelea striatula* - *Maetra corallina* descrita por Glémarec (1969, 1973) y con la de arenas finas bien calibradas poco profundas (SFBC) o arenas finas terrígenas (Pérès and Picard 1964; Ledoyer, 1968). Hacia la parte más profunda se aprecia una mayor abundancia de *Ophiura texturata*, así como un incremento de la proporción de fango. La comunidad más diferente se encuentra en un fondo con rocas en la parte norte de la bahía. Aproximadamente la mitad de las especies pertenecen a la provincia faunística europea templada (Atlanto-Mediterránea) y cerca de una cuarta parte a la provincia tropical del Oeste Africano. A pesar de lo limitado del muestreo, se citan cinco especies de moluscos nuevas para la fauna de Marruecos (*Nassarius goreensis*, *N. argenteus*, *Cuna gambiensis*, *Tellina rubicincta*, *Pandora oblonga*), lo que pone de manifiesto la necesidad de una prospección más intensa en este área.

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INTRODUCTION

The benthic fauna of the Atlantic coast of Morocco is known quite adequately for bathyal environments sampled by deep-sea expeditions (see review in SALAS, 1996 and GARCÍA RASO, 1996) or for the intertidal communities accessible from the shore. The subtidal environments in between have received little attention and their species composition remains largely unknown. Previous data are mainly based on a sampling programme conducted in the years 1924-1925 with the trawler "Vanneau", following the foundation of the Institut Scientifique Chérifien, Morocco's Natural History Museum in 1923 (LIOUVILLE, 1930). However, only a small part of the material obtained was eventually studied.

The geographical situation of the Bay of Agadir falls mid-way within the so-called "Mauretanian region" of EKMAN (1953). Thus, it is important to determine how much of its fauna belongs to the European temperate province, as does most of Atlantic Morocco, and how much belongs to the tropical West African province. The bay marks the end to the north of a very long stretch of coastline with a broad shallow continental shelf clad with sediments, and bordered by long, straight sandy beaches exposed to heavy surf. Northwards, Cape Ghir sets a sharp physiographic limit to a predominantly rocky shore with a narrow platform; a comparable sandy shore resumes only much further to the north along the coastal plains of Bouregreg and Sebou in Northern Morocco. Thus, this physical boundary may contribute to sharpen the northwards boundary of any West African elements likely to occur in the area. The area of Agadir is also coincident with a major area of upwelling (MITTELSTAED, 1983), which makes it potentially species-rich.

The growing concern for conservation and control of water quality has triggered new interest for the benthos in nearshore environments close to the large urban agglomeration of Agadir.

The purpose of this paper is to present some results regarding the benthic macrofauna (chiefly Mollusca and Decapoda) of the soft bottoms which constitute most of the bay, and to draw some preliminary conclusions regarding benthic communities and their biogeographic setting.

MATERIAL AND METHODS

A set of samples (Figure 1) was collected in May 1999, using a rectangular dredge with an opening of 50 cm, geared with a net of 10 mm mesh. The dredge was towed by a boat at a speed of approximately one knot, for 15 minutes, parallel to shore at each position on a transect. Three transects were sampled perpendicular to shore, in the vicinity of Oued Souss, which was the target area for an environmental impact study, and within each transect four samples were taken at 10, 15, 20 and 25 m depth. Two other transects and some samples were taken with the same gear at the northern end of the beach (D), inside the harbour (E), and in front of the suburb of Anza (F), just northwest to the harbour. In each of the transects D and F, samples were taken, at 6, 10, 15, 20 and 25 m. Samples were sorted immediately upon return to the lab, and the animals preserved in 70° ethanol for further determination.

The literature used for species identification was not specific to the area. The fauna of both Western Europe and West Africa has been considered. PASTEUR HUMBERT (1962a, b), POPPE AND GOTO (1991, 1993) and the unpublished manuscript on West African Bivalvia by Rudo von Cosel (MNHN) were the basic references for the Mollusca; MONOD (1956), FOREST AND GANTES (1960) and ZARIQUEY ÁLVAREZ (1968), among others for the decapods, TORTONESE (1965) for the echinoderms. The polychaetes were identified by Patrick Gillet (of Institut d'Ecologie Appliquée, Angers, France).

Sediment samples were taken by SCUBA diving along the three transects of Oued Souss (A: 30° 18' N, B: 30° 20' N

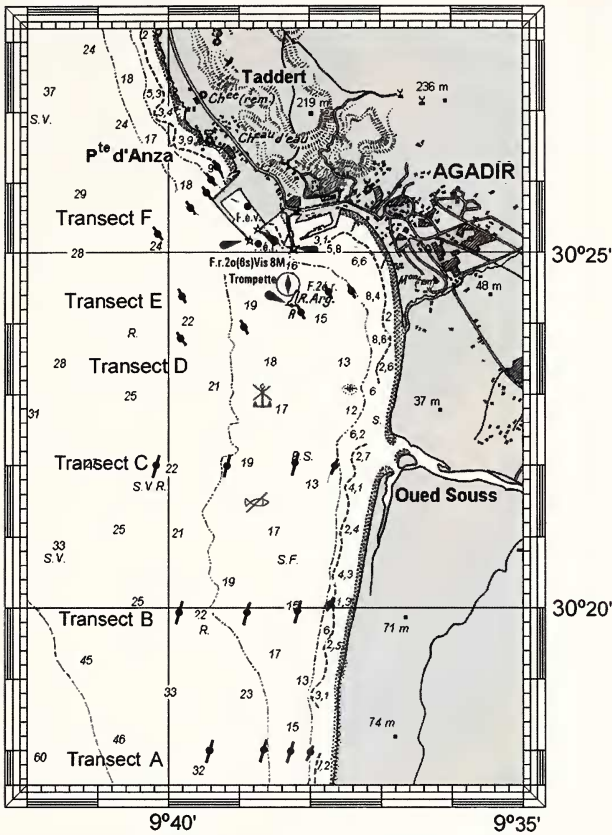


Figure 1. Map of the Bay of Agadir, with location of the sampling stations.
 Figura 1. Mapa de la bahía de Agadir, con la ubicación de las estaciones de muestreo.

and C: 30° 22' N), in order to determine granulometry using a column of standard sieves.

PRIMER software (CLARKE AND WARWICK 1994, CLARKE AND GORLEY, 2001) was used in the study of the structure of the communities and their spatial variations using qualitative data without transformation and standardization. Possible significant differences between transects and depths were assessed using the ANOSIM routine. Samples were grouped according to their faunal composition using the Bray-Curtis similarity index. In the cluster the mode group average was selected. The samples were then plotted with a non-metric multidimensional scaling (MDS routine) and, to know the level of contri-

bution of the different species, the SIMPER routine was applied.

RESULTS

The list of all collected species amounts to 70 (Table I). There is an increase in species richness with distance from shore. Molluscs and decapods are the best represented groups, whereas polychaetes probably were undersampled due to the kind of dredge used, which skims the superficial part of the sediment.

The sediments are essentially fine sands in transects A and C (range of median 0.17-0.32 mm). The pelite content is very low nearshore and

Table I. List of species collected in the dredgings. The * denotes species shared with “sables fins à *Venus gallina* - *Mactra corallina*” and “sables fins envasés à *Pharus legumen* - *Ophiura texturata*” or denoted as characteristic of fine sand communities by Glemarec (1969). W: West african species. The abundance of species is coded (1) 1-2 specimens, (2) 3-5 specimens, (3) 6-10 specimens, (4) over 10 specimens.

depth (m)	Transect 30° 18' N				Transect 30° 20' N			
	10	15	20	25	10	15	20	25
MOLLUSCA GASTROPODA								
<i>Bela</i> sp.								
<i>Bivetiella cancellata</i> (Linné, 1758)	W		2	1				
<i>Bulla miran</i> (Bruguière, 1792)	W	3	4	3	2	4	4	2
<i>Calyptrea chinensis</i> (Linné, 1758)								
<i>Clanculus kraussi</i> (Philippi, 1846)	W							
<i>Cabestana dolaria</i> (Linné, 1767)	W							
<i>Cymbium cucumis</i> Röding, 1798	W	1						
<i>Epitonium turtonis</i> (Turton, 1819)								
<i>Euspira fusca</i> (de Blainville, 1845)			1					
<i>Euspira pulchella</i> (Risso, 1826)			1					
<i>Marginella glabella</i> (Linné, 1758)	W							
<i>Mesalia varia</i> (Kiener, 1844)	W	2	4	3	1			
<i>Mitrella</i> sp.		1						
<i>Nassarius argenteus</i> (Marrat, 1877)	W							
<i>Nassarius elatus</i> (Gould, 1845)	W	2	4	1	1	1	1	
<i>Nassarius goreensis</i> (von Maltzan, 1884)	W							
<i>Nassarius incrassatus</i> (Ström, 1768)								
<i>Nassarius reticulatus</i> (Linné, 1758)		3	2	1				
<i>Nassarius vaucheri</i> (Pallary, 1906)	W	1			1		1	
<i>Ocenebra brevirobusta</i> Houart, 2000								
<i>Philine aperta</i> (Linné, 1758)								1
<i>Stramonita haemastoma</i> (Linné, 1758)								
<i>Solatia piscatoria</i> (Gmelin, 1791)	W	1	2	1	1	2	1	
<i>Tectonatica sagraiana</i> (d'Orbigny, 1844)	W							1
<i>Volvarina</i> sp.	W							
MOLLUSCA BIVALVIA								
<i>Anomia ephippium</i> (Linné, 1758)					1			
<i>Abra alba</i> (Wood, 1802)	*		1	1	4	1	1	2
<i>Chamelea striatula</i> (da Costa, 1778)	*						1	
<i>Corbula gibba</i> (Olivi, 1792)				2				2
<i>Cuna gambiensis</i> Nicklès, 1955	W							
<i>Donax vittatus</i> (da Costa, 1778)	*	2						
<i>Dosinia lupinus</i> (Linné, 1758)	*	1	1	1			1	
<i>Ensis ensis</i> (Linné, 1758)	*							
<i>Gari fervensis</i> (Gmelin, 1791)								
<i>Macoma cumana</i> (Costa, 1829)		1	1	1				
<i>Mactra corallina</i> (Linné, 1758)	*		1				2	2

Tabla I. Lista de especies recolectadas en los dragados. El * indica especies que se han citado para las comunidades denominadas "sables fins à Venus gallina - Mactra corallina" y "sables fins envasés à Pharus legumen - Ophiura texturata", o indicadas como características de comunidades de arena fina por Glemarec (1969). W: Especies Oeste-Africanas. La abundancia de las especies esta anotada como (1) 1-2 ejemplares, (2) 3-5 ejemplares, (3) 6-10 ejemplares, (4) más de 10 ejemplares.

Transect 30° 22' N				North of Beach					Harbour			Off Anza				
10	15	20	25	6	10	15	20	25	6	6	25	6	10	15	20	25
					2											
	1								1							
4	3	4		2	4	4	2		4	1		4	1	1	2	4
													1			1
												2				1
									1							
													1			
									1							1
2	1			4	4	1			1	4	1	4	2		3	2
	1								1						1	
				2		1				3		3		1	4	4
															2	
				3	4	1			2	4		4	2		1	1
				4						4		4	4	2	3	4
	1								4			1				1
									2							
									1							
										1						
	1					1				1					1	1
										1						
													1	1		
	1	1			2	1	1		4		3				1	2
					2	2			1	4	1	2	2	4	2	2
					2				1	2					1	4
																1
1				1	1		1		4				1	1		
		1	1		2				4				1	1		
	1				1		1		1				1	1	1	
																1
	1	1				1			4							
	2		1		1		1		2	3				1	1	

Table I. List of species collected in the dredgings. The * denotes species shared with "sables fins à Venus gallina - Mactra corallina" and "sables fins envasés à Pharus legumen - Ophiura texturata" or denoted as characteristic of fine sand communities by Glemarec (1969). W: West african species. The abundance of species is coded (1) 1-2 specimens, (2) 3-5 specimens, (3) 6-10 specimens, (4) over 10 specimens.

depth (m)	Transect 30° 18' N				Transect 30° 20' N			
	10	15	20	25	10	15	20	25
MOLLUSCA GASTROPODA								
<i>Bela</i> sp.								
<i>Bivettella cancellata</i> (Linné, 1758)	W		2	1				
<i>Bullia miran</i> (Bruguière, 1792)	W	3	4	3	2	4	4	2
<i>Calyptroea chinensis</i> (Linné, 1758)								
<i>Clanculus kraussi</i> (Philippi, 1846)	W							
<i>Cobestana dalania</i> (Linné, 1767)	W							
<i>Cymbium cucumis</i> Röding, 1798	W	1						
<i>Epitanium turtonis</i> (Turton, 1819)								
<i>Euspira fusca</i> (de Blainville, 1845)			1					
<i>Euspira pulchella</i> (Risso, 1826)			1					
<i>Marginella globella</i> (Linné, 1758)	W							
<i>Mesalia varia</i> (Kiener, 1844)	W	2	4	3	1			
<i>Mitrella</i> sp.		1						
<i>Nassarius argenteus</i> (Marrat, 1877)	W							
<i>Nassarius elatus</i> (Gould, 1845)	W	2	4	1	1	1	1	
<i>Nassarius gareensis</i> (van Maltzan, 1884)	W							
<i>Nassarius incrassatus</i> (Ström, 1768)								
<i>Nassarius reticulatus</i> (Linné, 1758)		3	2	1				
<i>Nassarius voucheri</i> (Pallary, 1906)	W	1			1	1		
<i>Ocenebra brevirabusta</i> Houart, 2000								
<i>Philina aperta</i> (Linné, 1758)								1
<i>Stramonita haemastoma</i> (Linné, 1758)								
<i>Salatia piscatoria</i> (Gmelin, 1791)	W	1	2	1	1	2	1	
<i>Tectanatica sagraiana</i> (d'Orbigny, 1844)	W							1
<i>Valvarina</i> sp.	W							

MOLLUSCA BIVALVIA

<i>Anomia ephippium</i> (Linné, 1758)						1								
<i>Abra alba</i> (Wood, 1802)	*		1	1	4	1	1	2						
<i>Chamelelea striatula</i> (da Costa, 1778)	*							1						
<i>Carbula gibba</i> (Olivi, 1792)					2									2
<i>Cuna gambiensis</i> Nicklès, 1955	W													
<i>Danax vittatus</i> (da Costa, 1778)	*	2												
<i>Dasinia lupinus</i> (Linné, 1758)	*	1	1	1				1						
<i>Ensis ensis</i> (Linné, 1758)	*													
<i>Gari fervensis</i> (Gmelin, 1791)														
<i>Macoma cumana</i> (Costa, 1829)		1	1		1									
<i>Mactra corallina</i> (Linné, 1758)	*		1											2

Tabla I. Lista de especies recolectadas en los dragados. El * indica especies que se han citado para las comunidades denominadas "sables fins à Venus gallina - Mactra corallina" y "sables fins envasés à Pharus legumen - Ophiura texturata", o indicadas como características de comunidades de arena fina por Glemarec (1969). W: Especies Oeste-Africanas. La abundancia de las especies esta anotada como (1) 1-2 ejemplares, (2) 3-5 ejemplares, (3) 6-10 ejemplares, (4) más de 10 ejemplares.

depth (m)	Transect 30° 22' N				North of Beach					Harbour			Off Anza					
	10	15	20	25	6	10	15	20	25	6	6	25	6	10	15	20	25	
MOLLUSCA GASTROPODA																		
<i>Bela</i> sp.								2										
<i>Bivettella cancellata</i> (Linné, 1758)												1						
<i>Bullia miran</i> (Bruguière, 1792)													4	1				
<i>Calyptroea chinensis</i> (Linné, 1758)																		
<i>Clanculus kraussi</i> (Philippi, 1846)																		
<i>Cobestana dalania</i> (Linné, 1767)																		
<i>Cymbium cucumis</i> Röding, 1798																		
<i>Epitanium turtonis</i> (Turton, 1819)																		
<i>Euspira fusca</i> (de Blainville, 1845)																		
<i>Euspira pulchella</i> (Risso, 1826)																		
<i>Marginella globella</i> (Linné, 1758)																		
<i>Mesalia varia</i> (Kiener, 1844)																		
<i>Mitrella</i> sp.																		
<i>Nassarius argenteus</i> (Marrat, 1877)																		
<i>Nassarius elatus</i> (Gould, 1845)																		
<i>Nassarius gareensis</i> (van Maltzan, 1884)																		
<i>Nassarius incrassatus</i> (Ström, 1768)																		
<i>Nassarius reticulatus</i> (Linné, 1758)																		
<i>Nassarius voucheri</i> (Pallary, 1906)																		
<i>Ocenebra brevirabusta</i> Houart, 2000																		
<i>Philina aperta</i> (Linné, 1758)																		
<i>Stramonita haemastoma</i> (Linné, 1758)																		
<i>Salatia piscatoria</i> (Gmelin, 1791)																		
<i>Tectanatica sagraiana</i> (d'Orbigny, 1844)																		
<i>Valvarina</i> sp.																		

MOLLUSCA BIVALVIA																		
<i>Anomia ephippium</i> (Linné, 1758)																		
<i>Abra alba</i> (Wood, 1802)																		
<i>Chamelelea striatula</i> (da Costa, 1778)																		
<i>Carbula gibba</i> (Olivi, 1792)																		
<i>Cuna gambiensis</i> Nicklès, 1955																		
<i>Danax vittatus</i> (da Costa, 1778)																		
<i>Dasinia lupinus</i> (Linné, 1758)																		
<i>Ensis ensis</i> (Linné, 1758)																		
<i>Gari fervensis</i> (Gmelin, 1791)																		
<i>Macoma cumana</i> (Costa, 1829)																		
<i>Mactra corallina</i> (Linné, 1758)																		

Table I. Continuation.

Tabla I. Continuación

depth (m)	W	Transect 30° 18' N				Transect 30° 20' N			
		10	15	20	25	10	15	20	25
<i>Modiolus stultorum</i> (Jousseaume, 1893)	W			1				1	
<i>Nuculana bicuspidata</i> (Gould, 1845)	W		3		1				
<i>Pandora oblonga</i> (Sowerby, 1830)	W								
<i>Pandora inaequalis</i> (Linné, 1758)			1	2		1			
<i>Parvicardium exiguum</i> (Gmelin, 1791)									
<i>Pharus legumen</i> (Linné, 1758)	*	1	1	2		2	1	2	1
<i>Phaxas pellucidus</i> (Pennant, 1777)	*							1	
<i>Scacchia zorni</i> van Aartsen & Fehr-de Wal, 1985									
<i>Sinupharus combieri</i> (Fischer-Piette & Nicklès, 1946)	W								
<i>Spisula subtruncata</i> (da Costa, 1778)	*		1		1				
<i>Tellina tenuis</i> (da Costa, 1778)	*	1							
<i>Tellina rubicincta</i> Gould, 1845	W				1				
<i>Tellina fabula</i> Gmelin, 1791	*		2	1				1	1
<i>Thracia papyracea</i> (Poli, 1791)	*		1						
<i>Thyasira flexuosa</i> (Montagu, 1803)					2				
MOLLUSCA CEPHALOPODA									
<i>Sepietta oweniana</i> (d'Orbigny, 1839)				2					
<i>Sepioloa rondeleti</i> Leach, 1817			2						
CRUSTACEA DECAPODA									
<i>Diogenes pugilator</i> (Roux, 1829)	*	3		3			4		
<i>Liocarcinus</i> cf. <i>halsatus</i> (Fabricius, 1798)	*	2	2	3		1	1	1	1
<i>Liocarcinus depurator</i> (Linné, 1758)									
<i>Macropodia rostrata</i> (Linné, 1761)					2				
<i>Philocheas trispinosus</i> (Hailstone, 1835)	*					3	1		
<i>Polybius henslowii</i> Leach, 1820			1				1		
<i>Scyllarus arctus</i> (Linné, 1758)									1
PYCNOGONIDA									
<i>Nymphon</i> sp.							1		
ECHINODERMATA									
<i>Echinocardium</i> sp.		1							
<i>Ophiura texturata</i> Lamarck, 1816	*			4	4	1		4	4
ANNELIDA POLYCHAETA									
<i>Cirratulus filiformis</i> Keferstein, 1862									
<i>Diopatra neapolitana</i> Delle Chiaje, 1841		1	1	4	4	1	2	3	3
<i>Lugia pterophora</i> (Ehlers, 1864)									
<i>Magellona papillicornis</i> Müller, 1858									
<i>Nephtys</i> sp.									1

Table I. Continuation.
 Tabla I. Continuación

Transect 30° 22' N				North of Beach					Harbour			Off Anza				
10	15	20	25	6	10	15	20	25	6	6	25	6	10	15	20	25
									1	4	1	2	2	3	4	
				4												
	1			4	4	3							1	3	3	
									3							
	1	1	1	1	1	1	2	1		1	1	1		1	1	
				1												1
	1			2	1					4	1		1	1	1	1
				2						3		1	2	3		
													2			
1			1		1				1	1	1				1	
			2	2					4							
<hr/>																
4	3			2								3				
2	2	2	1	2	2	3	1	1	4			3	1	2		2
2																
					1											2
2	3	3														
1		1	1				1	1					1			
<hr/>																
								1						1	1	
		4	4				2	4					2		4	
<hr/>																
1		3	4	1	3				1	1		1	3	1	3	3
					1										1	
									2	1						

Table I. Continuation.

Tabla I. Continuación

Medialia stultarum (Jausseume, 1893)

depth (m)	W	Transect 30° 18' N				Transect 30° 20' N			
		10	15	20	25	10	15	20	25
<i>Nuculana bicuspadata</i> (Gould, 1845)	W		3	1					
<i>Pandora ablanga</i> (Sowerby, 1830)	W				1				
<i>Pandora inaequivalvis</i> (Linné, 1758)			1	2	1				
<i>Parvicardium exiguum</i> (Gmelin, 1791)									
<i>Pharus legumen</i> (Linné, 1758)	*	1	1	2	2	1	2	1	
<i>Phaxos pellucidus</i> (Pennant, 1777)	*					1			
<i>Scacchia zorni</i> van Aartsen & Fehrdé Wal, 1985									1
<i>Sinupharus cambien</i> (Fischer-Piette & Nickles, 1946)	W								
<i>Spisula subtruncata</i> (da Costa, 1778)	*		1	1					
<i>Tellina tenuis</i> (da Costa, 1778)	*	1							
<i>Tellina rubicincta</i> Gould, 1845	W			1					
<i>Tellina fabula</i> Gmelin, 1791	*		2	1		1	1		
<i>Thracia papyracea</i> (Pall, 1791)	*		1						
<i>Thyasira flexuosa</i> (Mantagu, 1803)				2					
MOLLUSCA CEPHALOPODA									
<i>Sepietta oweniana</i> (d'Orbigny, 1839)				2					
<i>Sepiella randeleti</i> Leach, 1817			2						
CRUSTACEA DECAPODA									
<i>Diogenes pugilator</i> (Roux, 1829)	*	3		3			4		
<i>Liocarcinus cf. halsatus</i> (Fabricius, 1798)	*	2	2	3		1	1	1	1
<i>Liocarcinus depurator</i> (Linné, 1758)						2			
<i>Macropodia rastrata</i> (Linné, 1761)						2			
<i>Philocheras trispinusus</i> (Hallstone, 1835)	*				3	1			
<i>Polydora henslowii</i> Leach, 1820			1			1			
<i>Scyllarus arctus</i> (Linné, 1758)									1
PYCNOGONIDA									
<i>Nymphon</i> sp.							1		
ECHINODERMATA									
<i>Echinocardium</i> sp.		1							1
<i>Ophiura texturata</i> Lamarck, 1816	*			4	4	1		4	4
ANNELIDA POLYCHAETA									
<i>Cirratulus filiformis</i> Kieferstein, 1862									1
<i>Diapatra neopalitana</i> Oelle Chioje, 1841		1	1	4	4	1	2	3	3
<i>Lugia pterophara</i> (Ehlers, 1864)									1
<i>Magellana papillicornis</i> Müller, 1858							1		
<i>Nephtys</i> sp.								2	1

Table I. Continuation.

Tabla I. Continuación

	Transect 30° 22' N				North of Beach					Harbour			Off Anza					
	10	15	20	25	6	10	15	20	25	6	6	25	6	10	15	20	25	
										1	4	1	2	2	3	4		
						4												
		1			4	4	3						1	3	3			
	1	1	1		1	1	1	2	1	3	1	1	1	1	1			
					1													1
	1				2	1				4	1		1	1	1	1		
					2					3			1	2	3			
														2				
	1		1		1					1	1	1			1			
					2	2				4								
	4	3			2									3				
	2	2	2	1	2	2	3	1	1	4			3	1	2			2
	2																	
						1												2
	2	3	3															
	1	1	1					1	1						1			
								1										1
								2	4							2		4
	1	3	4		1	3				1	1		1	3	1	3	3	
							1											
										2	1							

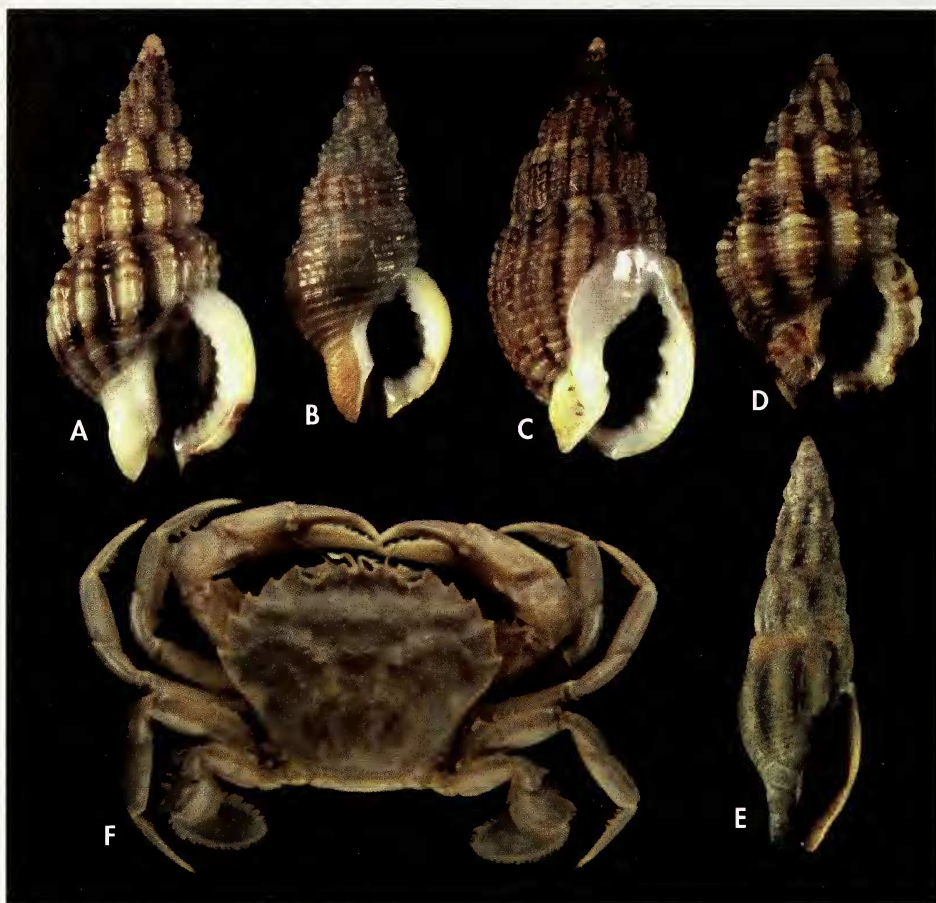


Figure 2 A-E. Gastropods from Agadir Bay. A: *Nassarius vaucheri* (Pallary, 1901), Agadir beach, 6 m (height 12 mm); B: *Nassarius argenteus* (Marrat, 1877), inside harbour, 15 m (height 7.4 mm); C: *Nassarius reticulatus* (Linné, 1758), Agadir beach, 6 m (height 16 mm); D: *Nassarius gorensis* (von Maltzan, 1884), off Anza, 20 m (height 9.3 mm); E: *Bela* cf. *zonata* (Locard, 1892), Agadir beach, 6 m (height 10.5 mm). Figure 2 F. Decapod Crustacean: *Liocarcinus* cf. *holsatus* (Fabricius, 1798), off Oued Souss, 15 m (breadth of carapace 36 mm).

Figura 2 A-E. Gasterópodos de la bahía de Agadir. A: *Nassarius vaucheri* (Pallary, 1901), playa de Agadir, 6 m (altura 12 mm); B: *Nassarius argenteus* (Marrat, 1877), en el puerto, 15 m (altura 7,4 mm); C: *Nassarius reticulatus* (Linné, 1758), playa de Agadir, 6 m (altura 16 mm); D: *Nassarius gorensis* (von Maltzan, 1884), frente a Anza, 20 m (altura 9,3 mm); E: *Bela* cf. *zonata* (Locard, 1892), playa de Agadir, 6 m (altura 10,5 mm). Figura 2 F. Crustáceo Decápodo: *Liocarcinus* cf. *holsatus* (Fabricius, 1798), frente al Oued Souss, 15 m (ancho del caparazón 36 mm).

increases to ca. 10% at 20 m. The values in transect B, under the influence of Oued Souss, show a higher content of pelites at shallower depths (up to 30% at 10 m depth). The northernmost transects, off the harbour and F, contain also some rocky outcrops.

Taxonomic and biogeographic notes on some species

MOLLUSCA GASTROPODA

Family Turritellidae

Turritellids are represented by one species of *Mesalia*, the same one that extends northwards to the Ibero-Moroc-

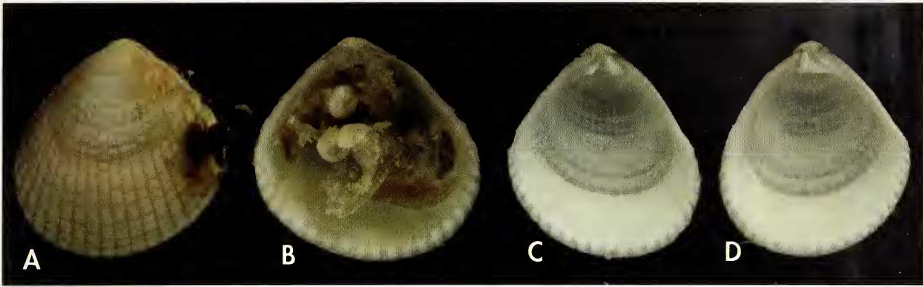


Figure 3. *Cuna gambiensis* Nicklès, 1955 from Agadir Bay, from "Vanneau" sta. 118 (30° 40' N, 09° 55' W, 20 m). A: Outside view of the left valve of a live-collected specimen; note the hydrozoan on posterior edge (actual height of shell 3.0 mm). B. inside view of the same valve with dried soft parts inside, note the four juveniles in prodissoconch stage incubated in the pallial cavity. C-D. Inside of left and right valve of another specimen (actual size 2.9 mm).

Figura 3. *Cuna gambiensis* Nicklès, 1955 de la bahía de Agadir, campaña del "Vanneau" est. 118 (30° 40' N, 09° 55' W, 20 m). A: Vista externa de la valva izquierda de un ejemplar recolectado vivo; nótese el hidrozoo asentado en el borde posterior (altura de la concha 3,0 mm); B: vista interna de la misma valva con partes blandas desecadas; nótese los cuatro juveniles en estadio de prodissoconcha, incubados en la cavidad paleal. C-D. interior de las valvas izquierda y derecha de otro ejemplar (altura 2,9 mm).

can Gulf and to the Alboran Sea and southwards to Senegal. There has been considerable confusion regarding the taxonomy of this species, often misidentified as the Senegalese endemic *Mesalia brevisalis* (Lamarck, 1822) (e.g. PASTEUR-HUMBERT, 1962a: 39). We agree with PALLARY (1900) and MARCHE-MARCHAD (1981) in considering that this is a distinct species, correctly named *Mesalia varia* (Kiener, 1844).

Family Nassariidae

This family is represented in our material by seven species, of which two are new to the Moroccan fauna. Nassarids are well represented in West Africa (see Adam and Knudsen, 1984) and are mostly scavengers. *Bullia miran* is one of the largest species and is a conspicuous element of the assemblage. It is a West African species, already mentioned from Agadir Bay by PALLARY (1920: 37, as *Dorsanum miran*) and PASTEUR-HUMBERT (1962a).

Nassarius vaucheri (Fig. 2A) and *Nassarius argenteus* (Fig. 2B) are two very similar species, the former endemic to the Ibero-Moroccan gulf and the latter West African, which could be suspected

of being geographical subspecies one of the other. The occurrence at Agadir of *N. argenteus* documents a range extension into Morocco, and supports their treatment as separate species.

Nassarius goreensis (Fig. 2D) is also a West African species new to the Moroccan fauna. Besides this occurrence, there are occasional findings as far north as Asilah and Tangiers (36° N; specimens in Muséum National d'Histoire Naturelle, Paris, collected by S.G.).

Nassarius reticulatus (Fig. 2C) conversely, is a member of the temperate West European fauna which reaches here its southern limit.

Family Muricidae

Ocenebra brevirobusta is a Moroccan endemic, formerly identified as *Ocenebra torosa* (Lamarck, 1816) or *Ocenebra erinaceus* (Linné, 1758) (see PALLARY, 1920; PASTEUR-HUMBERT, 1962a). HOUART (2000) described it as a new species, from material collected at Essaouira, some 100 km north of Agadir.

Family Turridae

There is one species of *Bela* (Fig. 2E) which resembles both morphologically

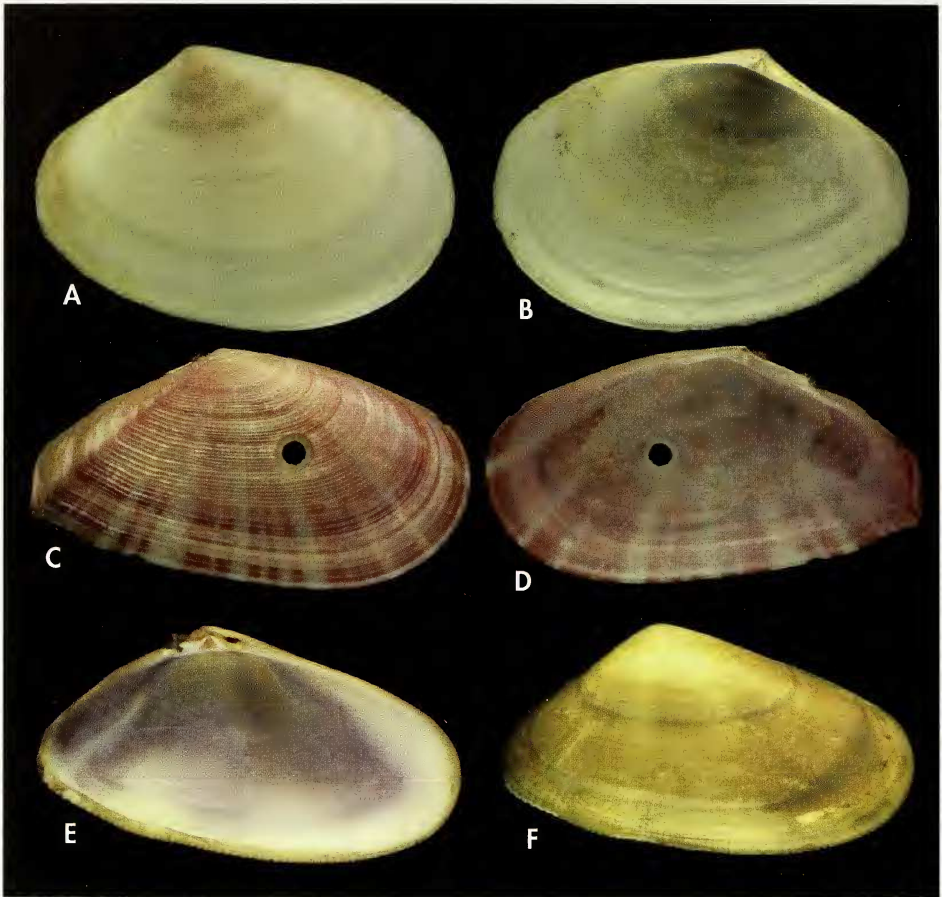


Figure 4 A-F. Bivalves from Agadir Bay. A, B: *Macoma cumana* (Costa, 1829), right valve, South of Oued Souss, 15 m (length 20 mm); C, D: *Tellina rubicincta* Gould, 1845, right valve, off Anza, 25 m. (length 22 mm); E, F: *Donax vittatus* (da Costa, 1778), left and right valves, off Anza, 10 m (length 21 mm).

Figura 4 A-F. Bivalvos de la bahía de Agadir. A, B: *Macoma cumana* (Costa, 1829), valva derecha, sur de Oued Souss, 15 m (longitud 20 mm); C, D: *Tellina rubicincta* Gould, 1845, valva derecha, frente a Anza, 25 m. (longitud 22 mm); E, F: *Donax vittatus* (da Costa, 1778), valvas izquierda y derecha, frente a Anza, 10 m (length 21 mm).

and in habitat the Mediterranean species *Bela zonata* (Locard, 1892), but there is such confusion in the species-level taxonomy of European *Bela* that we prefer not to venture a specific name.

MOLLUSCA, BIVALVIA

Family Condylardiidae

Cuna gambiensis (Fig. 3) is a small bivalve living in algal turf and thus linked to hard bottom. A few specimens

were collected in the transect off Anza, but there are many specimens from Agadir collected in the years 1920 by G. Dollfus with R/V "Vanneau" (unpublished material in Muséum National d'Histoire Naturelle, Paris). This is a tropical West African species, new to the Moroccan fauna. Live-taken specimens showed a small hydrozoan growing on the posterior edge of the valve, and, like other species of the Condylardiidae

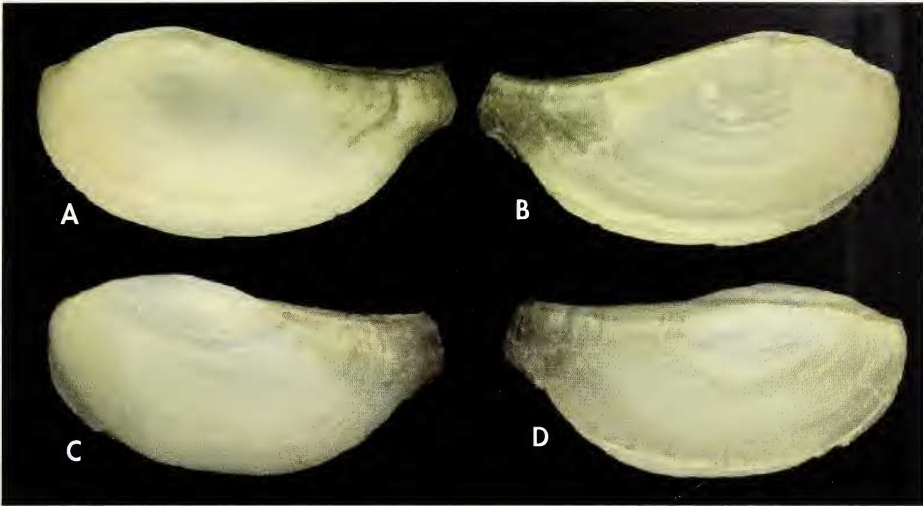


Figure 5 A-D. *Pandora* spp. from Agadir Bay. A-B: *Pandora inaequivalvis* (Linné, 1758), Agadir beach, 6 m (length 24 mm); C-D: *Pandora oblonga* (Sowerby, 1830), Agadir beach, 6 m (length 14 mm).

Figure 5 A-D. *Pandora* spp. de la bahía de Agadir. A-B: *Pandora inaequivalvis* (Linné, 1758), Agadir beach, 6 m (length 24 mm); C-D: *Pandora oblonga* (Sowerby, 1830), Agadir beach, 6 m (length 14 mm).

(SALAS AND ROLÁN, 1990; SALAS AND COSEL, 1991) it was found brooding juveniles.

Family Pharidae

The sand-dwelling razor shells are represented by four species. It is noteworthy that the genus *Ensis*, represented by three species in comparable sandy beaches of the Ibero-Moroccan Gulf, is here only represented by the smaller (and usually rarer) *Ensis ensis*. The West African *Sinupharus combieri* was already recorded (BELLON-HUMBERT, GLÉMAREC AND GOFAS, 1975), but the record of the European *Phaxas pellucidus* is a range extension, the known southern limit being Tangiers.

Family Tellinidae

Macoma cumana (Fig. 4A-B) has its type locality in the Western Mediterranean and is reported to have a West African range (von Cosel, unpublished data), but its distribution is quite puzzling, being replaced in the Alboran Sea by the very similar *Macoma melo* (Sowerby, 1866). The West African

species *Tellina rubicincta* (Fig. 4C-D) is new to the Moroccan fauna, the previously known northern limit being in Mauritania (DAUTZENBERG, 1910). It strongly resembles the European *T. distorta* Poli, 1791 but is larger, slenderer and with more distinct clamarginal lamellae towards the posterior end.

Family Donacidae

Donax vittatus was quite frequent in the sandy bottom of the shallower part of the transects. The specimens from Agadir (Fig. 4E-F) resemble the Mediterranean *D. venustus* (Poli, 1791) in having sometimes three broad radial bands, but should be assigned to *D. vittatus* on the basis of having striae which are not restricted to the part of the shell between the posterior angle and the posterior margin. The relationships of these species are still unsettled (TIRADO AND SALAS, 1999).

Family Veneridae

BACKELJAU, BOUCHET, GOFAS AND DE BRUYN (1994) have shown that the Atlantic populations formerly called

Venus gallina correspond to *Chamelea striatula*, whereas the real *Chamelea gallina* is restricted to the Mediterranean and southwestern Iberian Peninsula. This is an important point because the Atlantic species is the eponym of "sables fins à *Venus gallina*-*Mactra coralina*" of GLEMAREC (1969), to be corrected as *Chamelea striatula*-*Mactra coralina*. It is noteworthy that *C. striatula* is displaced towards more muddy facies where both species are sympatric, whereas, on the European West coast, it occupies facies of fine sand which are similar to the biotope of *C. gallina* in the Mediterranean.

Family Pandoridae

The shallow samples of the Agadir beach yield, in the same habitat, both the European *Pandora inaequivalvis* (Fig. 3D), here at its southern limit (range extension, previously known only from Essaouira northwards) and the West African *P. oblonga* (Fig. 3E), which is here recorded as new to the Moroccan fauna. *Pandora oblonga* is smaller, has a distinctly more convex left valve and more concave right valve, and is less rostrated posteriorly.

CRUSTACEA, DECAPODA

The genus *Diogenes* (Diogenidae) is represented in West Africa by a species complex (FOREST, 1961), but examination of the very large sample from Agadir bay suggests that only one species, *D. pugilator*, is present. The genus *Liocarcinus* (Portunidae) is represented by two species, the widespread *L. depurator*, and another one of doubtful identification (Fig. 2F), tentatively assigned to *L. cf. holsatus*, although the contour of the carapace resembles somewhat the Mediterranean *L. vernalis* (Risso, 1826). Nevertheless, specimens from Agadir lack the characteristic velvety surface of the latter. Material from intermediate localities on the Moroccan coast is needed to decide whether this is a geographical variation of one of these two European species, or if a third species must be considered. However, this group of species is in

revision (d'Udekem d'Acoz personal communication).

ANNELIDA: POLYCHAETA

There is a species of the genus *Diopatra* (family Onuphidae) which is abundant in all the transects of the bay. This may be *D. marocensis*, described from similar bottoms south of Safi (PAXTON, FADLAOUI AND LECHAPT, 1995). The number of Polychaete species in the samples is low, but this may be a bias due to our sampling gear which does not dig deeply into the sediments.

Characterization of the assemblages

The results of the aggregation and ordination analyses (MDS) using presence-absence data are shown in Figure 6, in which four main groups with a similarity above 50% are defined (stress value 0.18). The analysis of the grouped "stations" by transect shows significant difference (ANOSIM global test, $p = 0.003$), with highest values between the F and the A, B and C transects (pairwise tests, $p = 0.008$). In this way, the material collected off Anza and inside the harbour contain, in addition to the other assemblages, several species normally associated with rocky substrates. Among these are *Clanculus kraussi* and *Nassarius incrassatus*, found off Anza, and *Stramonita haemastoma*, *Ocenebra brevirobusta*, and *Cymatium doliarium* collected inside the harbour. The harbour appears comparatively species-rich (34 species), which can result both from the presence of hard substrates along the piers, and from the shelter of the piers which maintains low wave action.

Along the depth gradient a low significance differences have been found (ANOSIM Global test, $p = 0.04$).

A semi-quantitative analysis shows similar results (by transects: global test, $p = 0.002$), with highest values between the F and the A, B and C transects (pairwise tests, $p = 0.008$); by depth: global test, $p = 0.01$).

The average similarity within the different transects was around 40.1 (A) – 53.5% (F) (SIMPER) and between 9 (B) to

Stress: 0.18

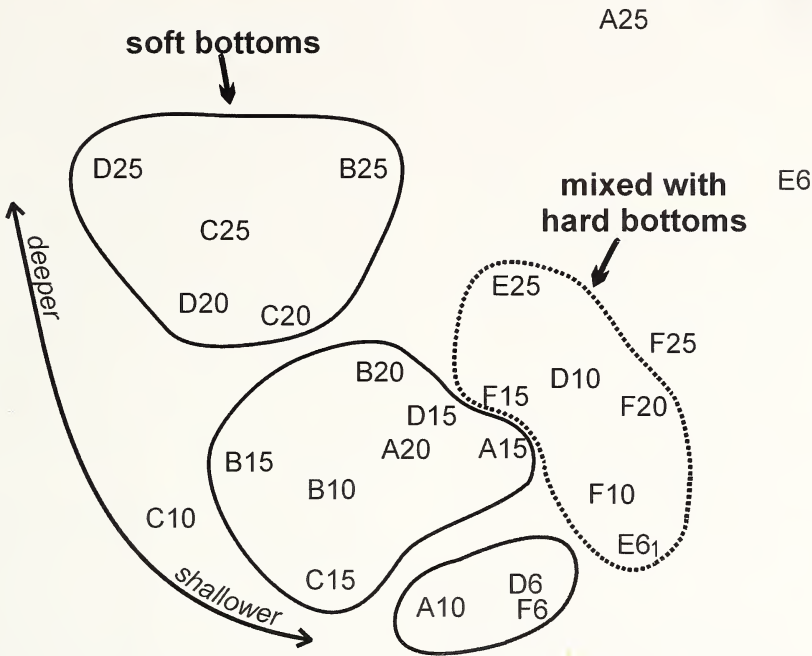


Figure 6. Multi-dimensional scaling (MDS) of the samples. The similarity matrix is based on presence/absence of the species and the Bray-Curtis similarity coefficient. The contours highlight groups of samples which cluster with a similarity coefficient above 50%. The samples are identified by a letter (A: radial of 30°18'N, B: radial of 30°20'N, C: radial of 30°22'N, D: North of Beach; E: Harbour, F: off Anza), and their depth.

Figura 6. Ordenación multidimensional (MDS) de las muestras. La matriz de similitud esta basada en la presencia/ausencia de las especies y en el coeficiente de similitud de Bray-Curtis. Los contornos señalan grupos de muestras que se juntan con un coeficiente superior a 50%. Las muestras están identificadas por una letra (A: radial de 30°18'N, B: radial de 30°20'N, C: radial de 30°22'N, D: Norte de la playa; E: Puerto, F: frente a Anza) y por su profundidad.

18 (F) species were necessary to get an accumulative contribution of 90-92 %. By depths, 10 (20m) to 14 (10 m) discriminating species are necessary to get a similar accumulative contribution (higher than 90%) with an average similarity between 35.3 (25 m) – 53.9% (15 m).

DISCUSSION

The species collected include some well known as characteristic of fine sands. The assemblages on soft bottoms are quite comparable to those reported

by GLEMAREC (1969, 1973) from “sable fin à *Venus gallina* - *Mactra corallina*” and “sables fins envasés à *Pharus legumen* - *Ophiura texturata*”, where many species (denoted by * on Table I) are shared. Some species collected here are restricted to rather low latitudes so that they have not been mentioned in any of the classical works on benthic bionomy. Among these, *Bullia miran*, *Nassarius elatus* and *Mesalia varia* are dominant and should qualify as characteristic of the fine sand or slightly muddy fine sand communities at the latitude of Agadir. The equivalence with the

Mediterranean community of "sables fins bien calibrés" SFBC (PÉRÈS AND PICARD, 1964, AUGIER, 1982) or of 'ter-rigenous' fine sandy bottoms (Ledoyer, 1968) is not straightforward because of these biogeographic differences, but many of the characteristic Mediterranean species are here replaced in the Atlantic Morocco by ecological vicariants: *Nassarius mutabilis* (Linné, 1758) by *Bullia miran*, *Nassarius pygmaeus* (Lamarck, 1822) by *N. goreensis*, *Chamelea gallina* (Linné, 1758) by *C. striatula*, *Tellina pulchella* Lamarck, 1818 by *T. rubicincta* and *Neverita josephina* Risso, 1826 by other Naticids. The same happens with the decapods, because the characteristic species of the SFBC community of the Mediterranean and southern Spain are *Diogenes pugilator*, *Philocheras trispinosus* and *Liocarcinus vernalis* (PÉRÈS AND PICARD 1964, LEDOYER, 1968, GARCÍA MUÑOZ, MANJÓN-CABEZA AND GARCÍA RASO, 2008) the latter replaced by *L. cf. holsatus* in this study. Such habitats are listed with very little detail, as sublittoral sands (code A5.2) in the European Nature Information System (EUNIS) classification (DAVIES, MOSS AND O'HILL, 2004).

The more differentiated assemblage found is that associated with sand and rocky substrate, which also shows the highest specific richness as usual in other areas (GARCÍA MUÑOZ ET AL, 2008).

The assemblages also respond to a bathymetric gradient: towards the deeper part of the transects, there is a set of species that prefer slightly muddy sands, the most noteworthy is *Ophiura texturata*. Nevertheless, the community is quite homogeneous along the shore,

even where facing the rocky area at Anza. This can be explained by the very flat topography of the sublittoral part of the bay, in which the sandy bottom swamps the rocky outcrops even north of the harbour. Also, the mobility of the macrofauna explains that some species are found across several neighbouring transects on the same kind of bottoms. The same happens in sublittoral bottoms of the Alborán Sea, where the decapod assemblage of coarse sandy bottoms (with high values of organic material) presented practically the same discriminating species as the neighbouring assemblage of muddy fine sandy bottoms, but with different quantitative contribution of the species (GARCÍA MUÑOZ ET AL, 2008).

A macrobenthic assemblage from fine sand bottoms in a depth range 16-40 m off Sidi Boulbra (31° 52' to 31° 58' N, some 160 km northwards, in the province of Safi), was described by FADLAOUI (1994) in an environmental study for a conventional thermic power plant. This was assigned to "sédiments fin plus ou moins envasés à *Abra alba-Diopatra brevicirris*", referring to a classification of benthic communities derived from THORSON (1957), but is basically similar to the assemblages referred herein. We suspect that the unidentified "terebrid" (FADLAOUI, 1994: 58) reported there with a frequency of 80% is *Bullia miran*, since there are no terebrids in Morocco and shells of *Bullia* are morphologically very terebrid-like.

Biogeographic notes

Among the 70 species collected, 20 (28.5 %) have a predominantly tropical distribution and can be considered as belonging to the West African zoogeo-

(Right page) Figure 7. Plot of the latitudinal ranges of the molluscan species known from Agadir Bay, ordered by southern (◆) and thence by northern (■) distributional limits; ranges in the southern hemisphere not shown and not taken into account for ordering.

(Página derecha) Figura 7. Representación de la extensión latitudinal de las especies conocidas en la Bahía de Agadir, ordenadas por límite sur (◆) y luego por límite norte (■) de distribución; no se muestran, ni se tienen en cuenta para la ordenación, las distribuciones en el hemisferio sur.